

# **Solution Mining Research Institute**

San Antonio, TX October, 2000

## **MULTIPHASE FLOW AND CAVERN ABANDONMENT IN SALT**

Brian Ehgartner & Vince Tidwell

Sandia National Laboratories\*  
Albuquerque, NM 87185-0706

### **ABSTRACT**

Although the deposition of salt requires water, most salt deposits (particularly domal salts) are invariably saturated with gas. It is hypothesized that the long-term state of an initially liquid-filled cavern in gassy salt will be gas filled. With the interest in using caverns for waste disposal, the long-term state of a cavern must be known. This raises such questions as: Under what conditions does gas migrate into a salt cavern? Under what conditions does salt imbibe liquids? Over what time scales do these processes operate? How does gas and liquid flow influence the mechanical behavior of salt? What is the equilibrium state of a salt cavern?

Unfortunately the mechanisms governing multiphase flow in low porosity/permeability materials are poorly understood. Here, we evaluate two different visualization techniques with respect to their ability to investigate processes governing the long-term performance of salt caverns: X-ray absorption and light transmission imaging.

Multiphase flow visualization experiments were conducted on a 10 cm diameter by 2.5 cm thick core of salt. Prior to its assembly into a flow cell, a 2.5 cm diameter hole was cut through the center of the core. The permeability and porosity of the air-dry core were tested, and yielded estimates of  $4.5 \times 10^{-18} \text{ m}^2$  and 0.007, respectively. Visualization experiments were initiated by filling the inner core hole with a brine solution doped with a tracer. Approximately 40 cm of head was applied to the solution in the inner core hole, while the outer edge of the salt core was maintained at atmospheric gas pressure.

Visualization was accomplished by focusing X-rays or light on the front of the test cell, while noting that the energy transmitted through the salt core is proportional to the concentration of tracer (salt and blue dye, respectively) integrated over the thickness of the core. Data acquisition was accomplished with the aid of a CCD (Charged Couple

Device) camera, which digitizes the transmitted energy field into 4096 gray-levels of resolution. In this way, two-dimensional images with  $0.01 \text{ mm}^2$  spatial resolution are acquired of the salt core at multiple times throughout the experiment.

Results of the experiment revealed that X-ray imaging was not capable of resolving the fluid distribution within the core due to the very low porosity. Fortunately, the light transmission technique was successful. Over 600 light images were acquired during the three-day experiment. Processing of the images yielded four important results: 1) Fluid flow in the salt core was successfully observed using the light transmission technique, 2) Rapid (few minutes to transverse the core) flow of liquid occurred along planes of visible salt damage, 3) At the end of 3 days, dye was visible throughout the core, even in areas unsuspected of damage, and 4) Migration of the dye occurred along crystal grain boundaries as evidenced by visual observation and digital image processing.

The observed ease at which two phase flow occurs in salt suggests that the mechanism of gas intrusion into a cavern and subsequent fluid evacuation from the cavern and imbibing into the salt is possible. Future study is planned to quantify further the multiphase flow properties relevant to cavern abandonment issues in salt.

---

\* Work supported by John Ford, U.S. Department of Energy, National Petroleum Technology Office, Tulsa, OK. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

## INTRODUCTION

The presence of gas in salt is well known. Both mines and caverns experience gas intrusion during their operational life. This process is expected to continue after an underground excavation is plugged and abandoned. The result of which may be the formation of a gas cap in the cavern. The continued development of a gas cap would displace cavern fluids into the salt. It is hypothesized that eventually the cavern would be completely gas filled as is observed on a small scale in naturally occurring salt inclusions. If such a process occurs, the implications on waste disposal in caverns and its migration must be understood. On the beneficial side, a gas filled cavern could have considerable economic value. This may change how industry decommissions caverns and sites that are no longer needed.

## BACKGROUND